# PATENT SPECIFICATION

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COMPLETE SPECIFICATION

## Improvements in or relating to Heat Exchangers

We, W. J. FRASER & CO. LIMITED, a British Company, of Harold Hill, Romford, Essex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention concerns sheet metal heat exchangers for effecting transfer of heat between two separated bodies of fluid. which include or consist of reciprocally folded sheets.

It has previously been the practice to close or seal the ends of reciprocally folded sheets by attachment thereto of a closure member, for instance a plate insert secured by welding; or alternately by clinching over the end regions so as to form smaller units which can be sealed separately.

An object of the present invention is to provide an improved end closure for such folded sheet metal portions, which enables their ready incorporation in a heat exchange installation.

Another object is to provide a construction which is especially suitable for incorporation in a container adapted to enclose a heated liquid and to be cooled by heat transfer to air or to another liquid surrounding such container which may for example be constituted by the tank of an electrical transformer.

According to the present invention in a method of making a heat exchanger having a container and a heat exchange pack consisting of two sets of interlaced contraflow passages, the steps comprise imparting a set to one edge region of a rectangular metal sheet by bending it adjacent and parallel to a first edge through an acute angle, a set being similarly imparted to another edge region by bending the sheet adjacent and parallel to a second edge disposed opposite to said first edge and successively folding the sheet alternately in opposite directions through two right angles about fold regions disposed at spaced intervals from one another and extending transversely between said first and second edges, the set edges of each alternate pair of wall portions which are substantially contiguous being united along their line of contact by metal fusion, each pair of adjacent wall portions being thereby adapted to form a transversely open heat exchange passage.

The set may be of the order of 50° at a distance from the edge depending upon this angle and upon the desired width of flow passage.

For containers such as transformer or switch-gear tanks in which a liquid is required to dissipate its heat to air surrounding the container, the sets in the sheet, before folding, are arranged in the same direction relative to the plane containing the central or unset portion thereof, that is to say they are both to the same face of the sheet. The result of this is to provide a similar closure of both side edges of each pair of folded wall portions, thereby forming closed pockets.

If, however, a heat exchanger is required for contraflow action between two gases, or for other purposes where symmetrically closed pockets are unsuitable, it may be preferable to impart these sets in opposite directions, whereby after folding the contiguous edges of adjacent wall portions are staggered alternately at opposite side edges of the reciprocally folded portion.

The treatment of the set portions around the 180° or other reciprocal bend will depend upon whether at that bend the set is in an inward or in an outward direction. If inward, the set portion may be bent round sharply by nipping, or a natural sharp bend may be used and the region may be bent around a mandrel of circular or other appropriate shape to avoid excessive curvature or stress. On

the other hand, when the flanging is outwardly directed at the bends the excess length of the edge may be shaped to leave the edge portion in the region of the bend lying at 90° to the adjacent contiguous edges.

For transformer casings or other containers for liquids the cover or base of the container to be sealed or joined to the ends of the reciprocally folded sheet metal portion may be bolted to a flange welded to the mutually parallel wall portions along the line of outwardly set bends lying, as described above, at 90° to the contiguous joined edges.

The invention will now be described further by way of example with reference to the accompanying purely diagrammatic drawings in which:—

Fig. 1 is a perspective view of part of a rectangular metal sheet having set edge regions substantially parallel one to the other and indicating the fold regions;

Fig. 2 is a perspective view of part of a folded metal sheet showing the end closures;

Fig. 3 is a plan corresponding to Fig. 2;

Fig. 4 is a perspective view of a heat exchange installation, the outer casing being broken away to expose its internal structure of mirror image folded sheets the set edge regions of which are as shown in Figs. 1 and 2;

Fig. 5 is a detail showing the flanging for sealing the folded metal sheet structure in the casing, and also a wedge-shaped supporting piece;

Fig. 6 is another detail of the flanging showing a connection between it and the outer casing;

Fig. 7 is a detail of an end closure between the mirror image folded metal sheets;

Fig. 8 is a section taken on the line VIII—VIII of Fig. 4;

Fig. 9 is a perspective view, with the front end of the casing displaced for clarity, of a heat exchange installation having an internal structure comprising double mirror image folded metal sheets; the set edge regions of which are as shown in Figs. 1 and 2;

Fig. 10 is a perspective view of a heat exchange installation showing a folded metal sheet internal structure the set edge regions of which are to the same face of the sheet;

Fig. 11 is a perspective view of part of the wall structure of a transformer tank including a folded metal sheet wall portion the set edge regions of which are to the same face of the sheet; and

Fig. 12 is a plan view of a tank the walls of which are fitted with one or more heating or cooling elements formed of a folded metal sheet the set edge regions of which are to the same face of the sheet.

A rectangular metal sheet has an upper surface 10 and an under surface 11 as shown in Fig. 1. A preliminary set is given to one edge region 12*a* of the sheet 10, 11 by bending it adjacent and parallel to a first side edge 12 through an acute angle $\phi$ in an upward direction. Similarly a preliminary set is given to an opposite edge region 13*a*, of the sheet 10, 11 by bending it adjacent and parallel to a second side edge 13 through an acute angle $\phi$ in a downward direction. The sheet is then successively folded alternately in opposite directions through approximately 180° about equally spaced fold regions A, B, C, . . . etc., which extend transversely between the edges 12 and 13 of the sheet.

The folding of the flat portion of the sheets may be effected in a conventional folding machine. The set edges, which are outside the folding tool limits, assume a curved contour at the fold regions which are shaped in the manner described hereunder.

Wall portions 10*a*, 10*b*, 10*c* etc., are thus formed and the side edges 12 or 13 of each alternate pair of adjacent wall portions are substantially contiguous and can now be united by welding, brazing or other suitable process of metal fusion without the use of filler pieces.

At the 180° bends, inwardly directed set portions 14 of edge regions 13*a* are bent round sharply by nipping or a natural sharp bend may be used and the region 14 may be bent around a mandrel of circular or other appropriate shape to avoid excessive curvature or stress. The excess lengths of the outwardly directed set portions at the 180° bends, are shaped to leave the edge portion 15 of the edge regions 13*a* lying at 90° to the adjacent contiguous edges 12 or 13.

The edge portions 15 are thus substantially in one plane thus facilitating the attachment, by welding, of a metal strip such as a flange.

Passages 16*a* are thus formed having fluid-tight joints at one of their ends and openings at their other ends and these passages 16*a* are interlaced with passages 16*b* which have fluid-tight joints at the ends adjacent the open ends of passages 16*a* and openings at their other ends.

The sets of both edge regions 12 and 13 may, however, be to the same face of the sheet and the resulting passages 16*a* have fluid tight joints at both ends, these passages 16*a* being interlaced with passages 16*b* which are open at both ends.

The folded metal structure, herein-

after referred to as a "pack", which is described above can be incorporated in a heat exchange installation of the type diagrammatically illustrated in Fig. 4 to 8 which utilizes two mirror image packs. Two packs 21*a* and 21*b* are provided with a continuous flange 23 disposed about the four peripheral side edges of the combined packs and attached thereto by welding; a dividing wall 22 separates the two packs 21*a* and 21*b* along the major part of their length. A return portion of the flange 23 is bolted or otherwise secured to a casing 20 as shown in Fig. 6, gaskets being provided between the casing and the flange as required. The packs are not attached to the shell except by way of the flange, in order to allow for expansion along their length. Wedge shaped support members 24 are provided at intervals along the length of the casing 20 and project into the transverse openings of the fluid passages; these support members also form pressure deformation limiting means, along the length of the casing. At the free floating end of the packs a connecting means is provided consisting of a sheet metal angle 25 welded to the adjacent edge portions 15 of the two packs as shown in Fig. 7 thereby preventing the intermingling of the two fluid systems; such a metal angle is slightly deformable to ensure sealing between the two packs.

The upper ends of both metal sheets are welded at 22*a* to the dividing wall 22 and the lower ends of both metal sheets are similarly welded thereto at 22*b*. Alternate passages 16*a* and 16*b* are isolated from each other but similar passages 16*a* and 16*b* of the two packs 21*a* and 21*b* are connected to each other.

Entrance nozzle 26*a* and exit nozzle 26*b* are provided for a higher pressure fluid P1. Similarly entrance and exit nozzles 27*a* and 27*b* respectively are provided for a lower pressure fluid P2.

The higher pressure fluid P1 enters the pack through nozzle 26*a* and passes into alternate passages 16*b* of pack 21*b*. As these passages are closed at their other extremities and the dividing wall 22 stops short of such extremities the fluid P1 passes into corresponding passages 16*b* of pack 21*a* and from thence out of the casing by way of exit nozzle 26*b*. The lower pressure fluid P2 enters the casing at nozzle 27*a* and passes into alternate passages 16*a* of pack 21*a*. These passages 16*a* are open at the free floating extremities of the pack and the fluid P2 is guided by the back wall of the casing 20 and is diverted into corresponding passages 16*a* of pack 21*b* and from there out of the casing by way of exit nozzle 27*b*.

Fluid P1 and fluid P2 enter and leave the packs substantially at right angles but once inside the fluid flows in their respective interlaced passages are parallel and in opposite directions.

Fig. 9 shows how a double mirror image pack, similar to the mirror image pack shown in Figs. 4 to 8, can be assembled. Mirror image packs 31*a* and 31*b* are separated by dividing wall 32*a* and packs 31*c* and 31*d* are separated by dividing wall 32*b*. These two sets of mirror image packs are separated by dividing wall 33. The packs are secured to a casing 30 in the same manner as that described for the embodiment shown in Figs. 4 to 8, the isolation of the alternate fluid passages and also the free floating end closure between the two mirror image packs being performed substantially in the same manner.

The higher pressure fluid P1 enters the casing 30 at nozzle 36*a* and passes into alternate passages 16*b* of pack 31*d*. The free floating extremities of these passages 16*b* being closed and as the dividing plate 32*b* is curtailed in this region, the fluid P1 passes into corresponding alternate passages 16*b* of pack 31*d*; at the nozzle end of the pack 31*c* the fluid passes through the open ends of passages 16*b* striking the front wall and being diverted into the corresponding open ends of the alternate passages 16*b* of pack 31*b*. A similar operation now takes place for the flow of fluid through the alternate passages 16*b* of packs 31*b* and 31*a*, the fluid P1 finally emerging from the casing through nozzle 36*b*.

The lower pressure fluid P2 enters the casing 30 at nozzle 37*a* and passes into alternate passages 16*a* of pack 31*a*. The alternate passages 16*a* are open at the free floating extremities of the packs 31*a* and 31*b* and the fluid P2 thus strikes the back wall of the casing 30 and is diverted into corresponding passages 16*a* of pack 31*b*. The dividing wall 33 is supported in guides 34 on the internal back wall of the casing thus preventing fluid P2 from bypassing alternate passages 16*a* of pack 31*b*. The dividing wall 33 is however curtailed at the nozzle end of the casing to allow fluid P2 to pass into alternate passages 16*a* of pack 31*c*; these alternate passages 16*a* of packs 31*c* and 31*d* are closed at the nozzle end of the casing and a similar operation now takes place for the flow of fluid through the alternate passages 16*a* of packs 31*c* and 31*d*, the fluid P2 finally emerging from the casing through nozzle 37*b*.

As in the example illustrated in Figs. 4 to 8 the paths of the two fluids P1 and P2 in their respective interlaced pas-

sages are always substantially parallel and in opposite directions to each other.

Fig. 10 illustrates diagrammatically a further embodiment of a heat exchange installation in which the pack is formed from a folded metal sheet, the set edge regions of which are to the same face of the sheet, whereby one set of passages have fluid-tight joints at both ends formed by the set edges, these passages being interlaced with passages which are open at both ends.

A container 40 is provided with an entrance nozzle 41*a* at one end and an exit nozzle (not shown) at the opposite end for a low pressure fluid P2. One side wall of the container has an entrance nozzle 42*a* and an exit nozzle 42*b* for a higher pressure fluid P1.

Low pressure fluid P2 is admitted through nozzle 41*a*, passes through the open ended passages and is discharged at the opposite end of the container 40 through the exit nozzle (not shown). The higher pressure fluid P1 is admitted to the closed ended passages by way of nozzle 42*a* and is discharged at nozzle 42*b*. The two fluids are thus admitted to their respective interlaced passages at right angles to each other and the two fluid flows within their respective passages are parallel and in opposite directions.

Reciprocally folded metal sheets having set edges to the same face of the sheet, forming a plurality of mutually parallel wall portions and having end closures of the type previously described may be used to form part of a transformer wall, the mutually parallel wall portions projecting outwardly from the transformer container 50 as shown diagrammatically in Fig. 11. Partition walls or baffle plates 51 can be welded to some of the interiorly disposed bends of the mutually parallel wall portions. A flange 54 is welded to both the upper and lower edge portions 52 of the mutually parallel wall portions, which edge portions, as previously described, are substantially in one plane and are shaped to lie at 90° to the adjacent contiguous edges 53. A cover 55 and a base 56 may now be bolted to the return part of flange 54 as shown. The baffle plates 51 are curtailed both at the top and the bottom leaving a gap in these regions between them and the upper and lower flanges 54.

Cooling air P4 may enter the open ended flow passages from below and has a straight run through. Hot circulating oil P3 from the transformer container 50 enters the closed ended passages through the gap between the top of the baffle plate 51 and the upper flange 54, as shown by the broken arrow. The oil P3 is cooled by the air P4 and falls down to the bottom of the closed ended passages whilst the air is heated and rises to the top of the open ended passages. The cooled oil P3 re-enters the container 50 between the gap formed between the lower edge of the partition wall at the lower flange 54. The directions of entry of the two fluids into their respective interlaced passages are thus at right-angles to each other and the two flows within their respective passages are parallel and in opposite directions.

A folded metal structure of this type may also be used for vessel heating or cooling purposes as shown diagrammatically in Fig. 12. Mutually parallel wall portions 60, formed in the same manner as described for the embodiment shown in Fig. 11, form part of a vessel wall 61 and are directed toward the interior 62 of such a vessel. Open-ended passages 60*b* are interlaced with closed ended passages 60*a*, which latter convey heat from a heating source 63, the walls of these passages thus forming the heating elements.

When used for heating a hot fluid enters the closed ended passages 60*a* horizontally and is conveyed downwardly along these passages. Cold fluid, in the interior 62 of the vessel, due to the transfer of heat through the walls to the passages 60*b*, moves upwardly along the open-ended passages 60*b*. The two fluids enter their respective passages substantially at right angles and the two fluid flows in their respective passages are parallel and in opposite directions.

What we claim is:—

1. In a method of making a heat exchanger having a container and a heat exchange pack consisting of two sets of interlaced contraflow passages, the steps which comprise imparting a set to one edge region of a rectangular metal sheet by bending it adjacent and parallel to a first edge through an acute angle, a set being similarly imparted to another edge region by bending the sheet adjacent and parallel to a second edge disposed opposite to said first edge and successively folding the sheet alternately in opposite directions through two right angles about fold regions disposed at spaced intervals from one another and extending transversely between said first and second edges, the set edges of each alternate pair of wall portions which are substantially contiguous being united along their line of contact by metal fusion, each pair of adjacent wall portions being thereby adapted to form a transversely open heat exchange passage.

2. A method as claimed in Claim 1, in

which the resultant outwardly directed flange at the bends is shaped to leave the edge portion in this region lying at 90° to the adjacent contiguous edges.

3. A method as claimed in Claim 1 or 2, in which the sets of both edge regions before folding are to the same face of the sheet.

4. A method as claimed in Claim 1 or 2, in which the sets of the edge regions before folding are in opposite mutually parallel directions.

5. A heat exchanger including a container and one or more packs made by the method claimed in Claim 1, in which the or each pack forms part of an outer wall of the container.

6. A heat exchanger as claimed in Claim 5, in which the or each pack projects into the interior of the container.

7. A heat exchanger as claimed in Claim 5, in which the or each pack is outside the main body of the container.

8. A heat exchanger including a container and one or more packs made by the method claimed in Claim 3 or 4, in which the or each pack is arranged inside the container.

9. A heat exchanger including a container and two packs made by the method claimed in Claim 4, in which the two packs are disposed in mirror arrangement in the container.

10. A heat exchanger including a container and four packs made by the method claimed in Claim 4, in which the four packs are disposed in double mirror arrangement in a container.

11. A heat exchanger as claimed in Claim 9 or 10, in which a continuous flange is disposed, adjacent one end of the container, about the peripheral side edges of the combined packs.

12. A heat exchanger as claimed in Claim 8, 9, 10 or 11, in which pressure deformation limiting means are provided on the interior of the container walls.

13. A method of making a heat exchanger substantially as herein described with reference to and as illustrated in Figs. 1 to 3 of the accompanying drawings.

14. A heat exchanger constructed and arranged to operate substantially as herein described with reference to and as illustrated in Figs. 4 to 8 of the accompanying drawings.

15. A heat exchanger constructed and arranged to operate as herein described with reference to and as illustrated in Fig. 9 of the accompanying drawings.

16. A heat exchanger constructed and arranged to operate substantially as herein described with reference to and as illustrated in Fig. 10 of the accompanying drawings.

17. A heat exchanger combined with a container and constructed and arranged to operate substantially as herein described with reference to and as illustrated in Fig. 11 of the accompanying drawings.

18. A heat exchanger combined with a container and constructed and arranged to operate substantially as herein described with reference to and as illustrated in Fig. 12 of the accompanying drawings.

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PROVISIONAL SPECIFICATION
No. 2060, A.D. 1954

## Improvements in or relating to Heat Exchangers

We, W. J. FRASER & Co. LIMITED, a British company, of Harold Hill, Romford, in the county of Essex, do hereby declare this invention to be described in the following statement:

The present invention concerns heat exchangers for effecting transfer of heat between two separated fluid streams.

An object of the invention is to provide a heat exchanger which is relatively simple and cheap to manufacture, compact, and efficient in operation.

According to the present invention a heat exchanger is formed from a plurality of substantially parallel wall portions of sheet metal presenting relatively shallow flow passages bounded by opposite faces of a pair of wall portions, successive passages being connected alternately to one or other of two fluid systems, in such a manner that the general direction of flow of one fluid into and/or out of the heat exchanger is substantially at right angles to the general direction of flow of the other fluid into and/or out of the heat exchanger, whereas the general direction of flow of one fluid is substantially parallel to that of the other fluid within their respective flow passages. The said wall portions may be formed from individual metal sheets, but preferably a relatively long rectangular piece of sheet metal such as a drawn and/or rolled strip is folded back and forth a plurality of times through bends of approximately 180° to provide a plurality of generally parallel rectangular wall portions each portion being thus integrally connected by way of one of said bends to one adjacent portion at one of its ends or sides and to the opposite adjacent portion at its opposite end or side, adjacent por-

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tions being also interconnected by welding or the like with or without the use of filler pieces along sides or ends respectively disposed at right angles to the aforementioned ends or sides interconnected by said bends. For this interconnection by welding the respective edge regions of the said portions are conveniently flanged over towards one another and united by a seam of welding at the contiguous edges.

The flanging of the edge regions of a relatively long single piece, such as a strip, is preferably effected before folding, and then extends continuously along each side of the strip, the flange on one side projecting in the direction opposite to that of the flange at the other side, relative to the faces of the strip. Due to the bending over of edge regions of the piece of metal it is necessary to accommodate these edge regions at the bends in different ways. Where the flanging is directed towards the inside of the bend the flanges may be either bent sharply through 180° by nipping, or a natural sharp bend may be used or they may be bent around a circular mandrel to avoid excessive curvature or stress. On the other hand at the side of the pack where the flanging is outwardly directed at the bends the excess length of the edge may be shaped to leave the portion of the edge at the bend lying at 90° to the adjacent parallel edges.

The inlet or outlet connection to one set of passages may then be defined by at least part of the interior of a casing in which the assembly of interconnected wall portions is enclosed; and the fluid entering or leaving this passage system from or towards the said casing interior is guided between alternate pairs of wall portions by the shape of the original 180° bends. The other fluid is conducted into or out of its passage system by the sharper welded edge junctions at right angles to these bends. Since it is necessary to isolate the two passage systems from one another to prevent intermingling of the fluid streams the inlets and/or outlets of each system must be in communication with separate header spaces within or associated with the casing. For this purpose it has been found convenient to form the edge region, of each said 180° bend between adjacent wall portions formed from a single piece, to have an edge lying substantially at right angles to the two adjacent wall surfaces and extending in each direction up to a relatively sharp 90° bend at which point it merges into the welded junction between the pair of flanged edge portions. These substantially straight edges at the opposite ends of a 180° bend are then able to be aligned and connected to one another by welding, preferably using a triangular section filler piece to provide a continuously extending boundary for connection by welding or otherwise into a header space.

It is preferred to assemble two packs each formed from a single piece bent over as previously described into one casing in back-to-back mirror-image relationship, with a dividing plate separating the 180° bends at one end or side of one pack from the corresponding bends of the other pack. This construction enables inlet and outlet connections for one of the fluids to be mounted side by side at one end of the casing, the said fluid flowing directly along the casing in one direction and returning in the opposite direction back to the same end from which it entered the casing. Such a disposition of the inlet and outlet connections allows the packs to be mounted in a floating condition, i.e. attached to the casing at one end only, and hence reducing or substantially eliminating thermal stresses and if necessary enabling the packs to be detachably mounted on a flange.

According to another feature of the present invention two mirror image packs each composed of a single rectangular piece of sheet metal having its two side edge regions flanged over towards opposite faces of the piece and the piece being folded at intervals throughout its length alternately in opposite directions through two right angles to produce a plurality of substantially parallel wall portions, the flanged edges of pairs of adjacent wall portions being united by welding, the packs being assembled with a driving plate substantially in contact with one set of bends of each pack, the packs and plate being enclosed in a casing with inlet and outlet end connections for one fluid communicating respectively with passages between said wall portions having inlets or outlets presented at one end of said pack between adjacent united pairs of side edges, whereby said fluid flows longitudinally of said casing through passages in one pack and returns in the opposite direction through corresponding passages of the other pack, the casing also having inlet and outlet connections in its wall surfaces adjacent the casing end aforementioned for the other fluid which enters or leaves the passages presented between the remaining pairs of wall surfaces substantially at right angles to its general direction of flow therein, said directions being longitudinal of the casing and thus parallel to the flow directions of the first-mentioned fluid.

In one preferred form of construction

in accordance with the invention two mirror-image packs each formed from a single sheet metal piece or from two or more pieces joined together, are enclosed in a generally rectangular casing having an inlet and an outlet header and connection flange side by side at one of its ends for the fluid which enters and leaves the passage system by way of wall portion joined edges which were initially the side edges of each of the strips used for the pack. The dividing plate runs right up to this end of the casing and separates the inlet and outlet header chambers from one another. Near this end the outer corner edges of one end (constituted by the flanged over sides of the strips) of the packs are sealed by welding, using a triangular section bar as a filler piece, to the casing interior, thus separating these header chambers from the remainder of the casing interior after the corresponding edges of the uppermost and lowermost wall portions of each pack have also been sealed to the corresponding upper and lower wall surfaces of the casing. Just beyond this attachment position of one end of the packs, flanged inlet and outlet connection chambers are formed in the casing side walls, opposite one another. These connections serve for the fluid which passes into and out of the passage system terminating or starting in the 180° bends between adjacent wall portions.

The packs do not extend right up to the blind end of the casing interior and being only attached to the casing near its opposite end is permitted to float within the casing to allow for thermal expansion or contraction relative thereto. The space between the end of the packs and the blind casing end serves to transfer fluid which has passed through the passage system of one pack via a casing side wall inlet to the corresponding passage system of the other pack prior to passing out through the casing side wall outlet.

The dividing plate, which at its upper and lower longitudinal edges is sealed by welding to the correspondingly positioned end edges of the pieces used for the packs, terminates short of the pack ends nearest to the blind end of the casing, the adjacent edges of these ends being sealed to one another by welding with the use of a filler bar of obtuse angled isosceles triangular cross section. The passage systems communicating with the adjacent inlet and outlet at the casing end are thus connected to one another near the blind end of the casing in the region between this obtuse angled filler and the end of the dividing plate.

Heat exchangers constructed in accordance with the invention are especially suitable for low-pressure gas-gas exchange duties, for instance in $SO_2$—$SO_3$ converters. Moreover the packs may be shaped to fill a cylindrical shell, so that with balanced pressures between the two systems of passages high gas pressure may be employed. Spacers and/or stiffeners may be incorporated.

Advantages arising from the invention include a relatively low pressure drop across each passage system and provision for relief from thermal stresses without the need for the additional expense of a floating head. Moreover, the assessment of heat transfer and pressure drop characteristics is far simpler and the usual assumptive causes of error are not needed.

Moreover a truly countercurrent flow arrangement is obtained due to the parallel flow directions of the two fluids within the passages. The heat exchange efficiency is high because substantially all installed surfaces are effective for heat exchanging action. The unit is very compact and a larger effective area may be installed in a given space than with conventional heat exchangers. The heat exchanging surfaces may be readily cleaned on removal from the casing, since the open edges of the flow intervals are presented for easy cleaning unlike tubes which must be cleaned from the end.

A convenient sequence of construction starts by rolling oppositely directed sets into edge regions of a continuous strip, folding the strip into continuous reverse folds, bringing the flanged over or set regions at the bends into alignment with a hand tool or otherwise (unless this step is incorporated in the bending), and spacers (if used) are introduced and spot welded with the folds sprung. The pack is then checked and finally aligned and the edges of the flanged over regions of adjacent wall portions are welded together, conveniently by hand gas welding. A pair of mirror-image packs is now assembled and the partition plate fitted and tacked. The protruding longitudinal edges of the pack are then welded to the plate and the inner nipped sides of the packs tacked to it and the outer ones to a spacer bar. The floating end is then sealed with a triangular filler bar and the packs welded into the shell or casing using filler bars of triangular section.

By mounting the pair of packs, together with the end header connections, on a plate of rectangular outline with a rectangular aperture therein of size corresponding to the section of the end of the packs, a flanged detachable unit is provided which is mounted in the casing

by bolting to a complementary flange thereof.

Instead of housing the pack or packs in a generally rectangular casing, other casing shapes may be used. For example with a cylindrical casing there may be a diametrical longitudinally extending division plate with the length of each fold or wall portion varying with the varying distance of points on this plate from the cylindrical surface at right angles thereto. Alternatively packs of rectangular outline may be accommodated for pressure purposes within a cylindrical casing the end being sealed by a light section plate of circular outline having a rectangular central aperture sealed by welding to the rectangular end edges of the packs.

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## PROVISIONAL SPECIFICATION
No. 16890, A.D. 1954

# Improvements in or relating to Heat Exchangers

We, W. J. FRASER & Co. LIMITED, a British Company, of Harold Hill, Romford, Essex, do hereby declare this invention to be described in the following statement:—

The present invention concerns sheet metal structures, such as heat exchangers for effecting transfer of heat between two separated bodies of fluid, which include or consist of reciprocally folded sheets.

An object of the present invention is to provide an improved end closure for such folded sheet metal portions.

Another object is to provide a construction which is especially suitable for incorporation in a container adapted to enclose a heated liquid and to be cooled by heat transfer to air or to another liquid surrounding such container which may for example be constituted by the tank of an electrical transformer.

It has been previously the practice to close or seal the ends of reciprocally folded sheets by attachment thereto of a closure member, for instance a plate insert secured by welding; or alternately by clinching over the end regions so as to form smaller units which can be sealed separately.

According to the present invention the sheets, before folding, are given preliminary sets parallel to their side edges (these side edges eventually constituting the ends which are to be closed), so that on folding, the edges of each alternate pair of adjacent wall portions are substantially contiguous and readily united along their line of contact by welding or brazing. The set may be of the order of 45° at a distance from the edge depending upon this angle and upon the desired spacing.

For containers such as transformer or switchgear tanks in which a liquid required to dissipate its heat to air surrounding the container, the sets in the sheets (before folding) are arranged in the same direction relative to the plane containing the central or unset portion thereof. The result of this is to provide similar closure of both ends of each pair of folded wall portions, i.e. to form a closed pocket.

If, however, a heat exchanger is required for contra flow action between two liquids, or for other purposes where symmetrically closed pockets are unsuitable, it may be preferable to impart these sets in opposite directions, whereby after folding the contiguous edges of adjacent wall portions are staggered alternately at opposite ends of the reciprocally folded portion.

The treatment of the set portions around the 180° or other reciprocal bend will depend upon whether at that bend the set is in an inward or in an outward direction. If inward, the set portion may be bent round sharply by nipping, or a natural sharp bend may be used and the region may be bent around a mandrel of circular or other appropriate shape to avoid excessive curvature or stress. On the other hand, when the flanging is outwardly directed at the bends the excess length of the edge may be shaped to leave the edge portion in the region of the bend lying at 90° to the adjacent contiguous edges.

For transformer casings or other containers for liquids the cover or other portion of the container to be sealed or joined to the ends of the reciprocally folded sheet metal portion may be welded thereto along the line of outwardly set bends lying, as described above, at 90° to the contiguous joined edges, with or without the use of a filler piece.

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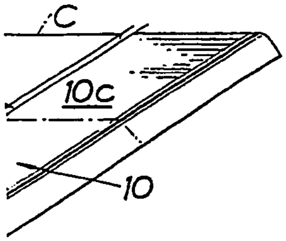
3 SHEETS    This drawing is a reproduction of the Original on a reduced scale
Sheets 1 & 3

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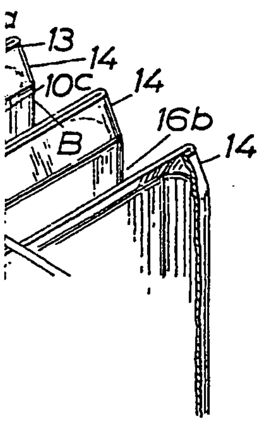
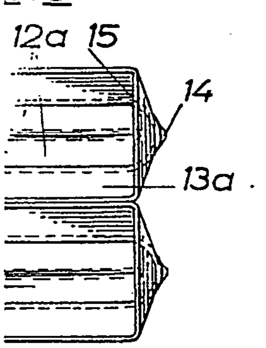
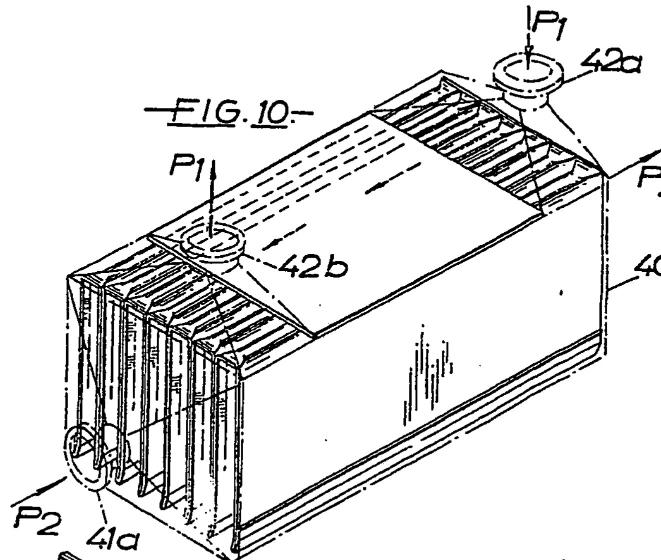


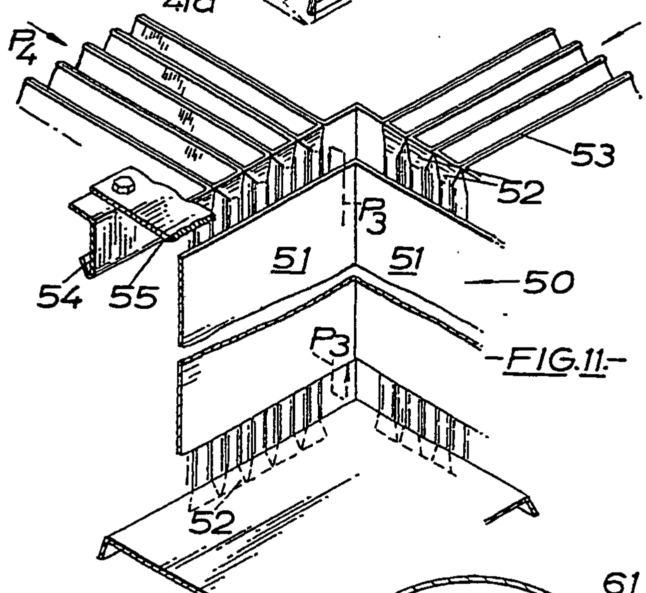

-FIG. 2-

G. 3-

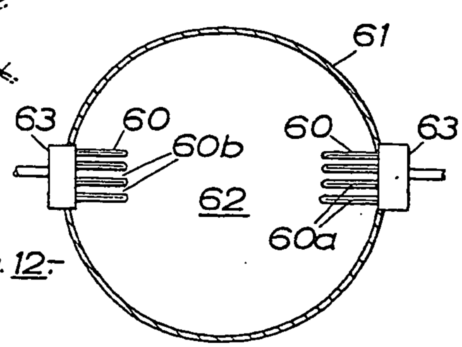



-FIG. 10-



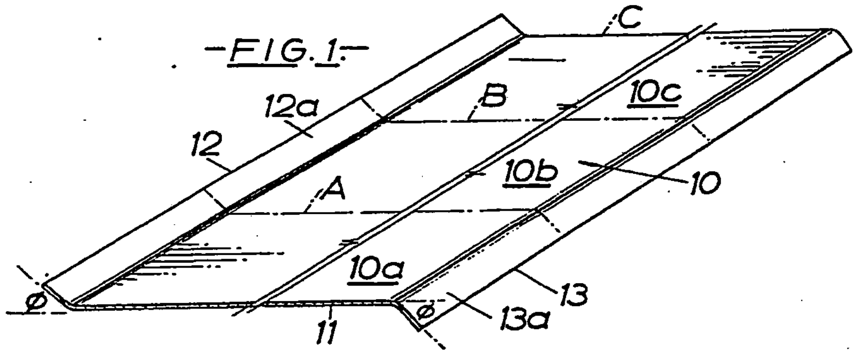



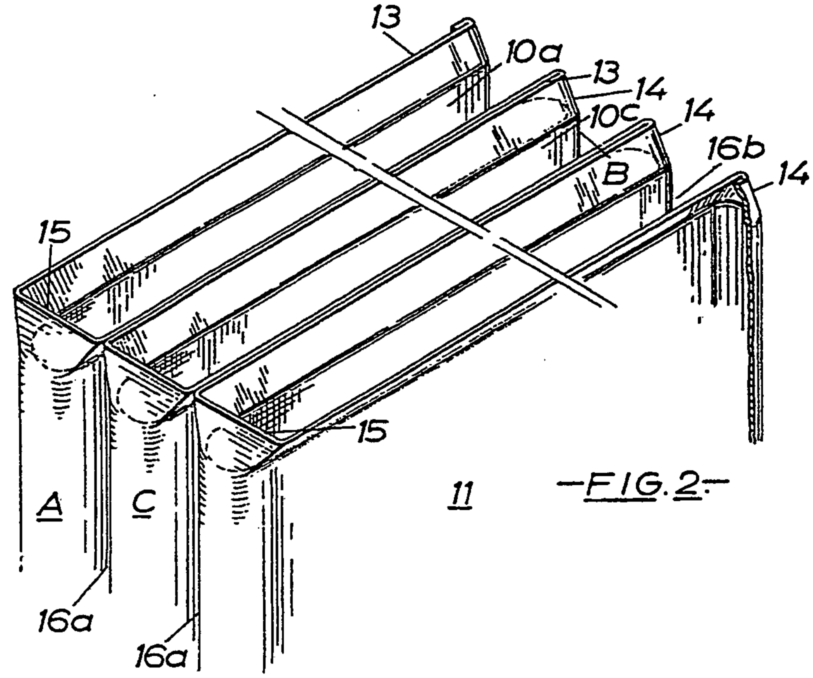

-FIG. 11-




-FIG. 12-

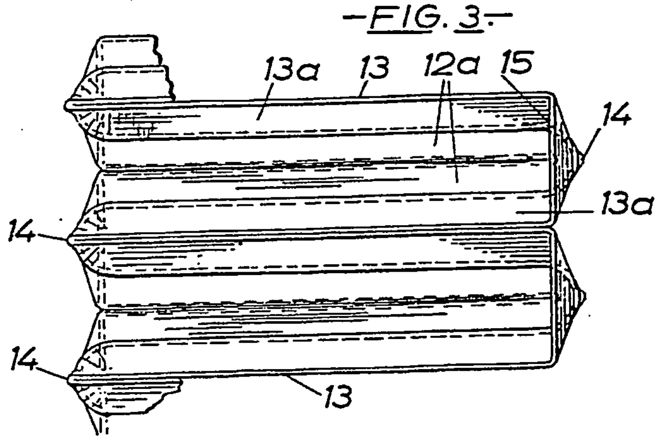
-FIG. 1-




-FIG. 2-

-FIG. 3-



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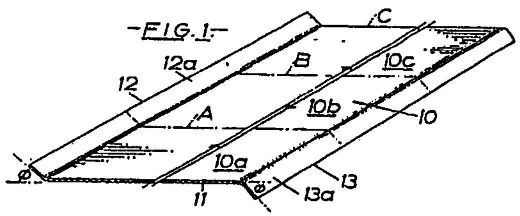
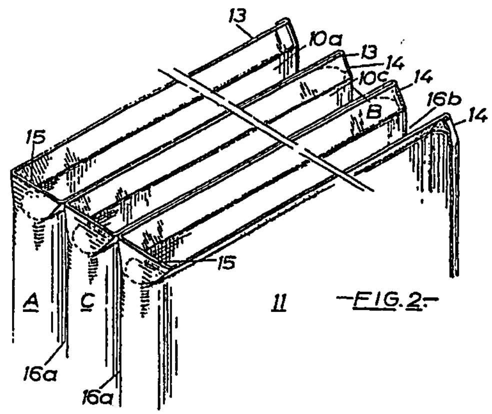
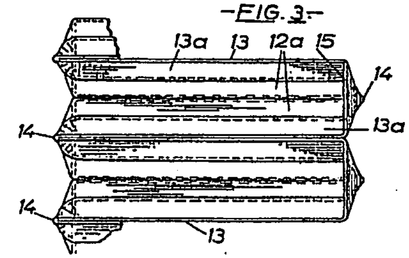
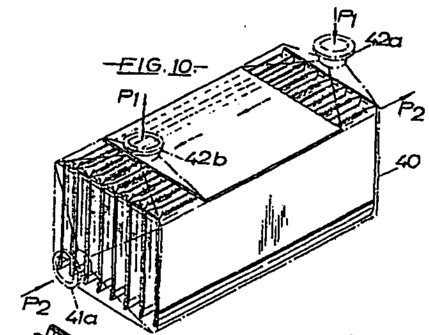
Sheets 1 & 3

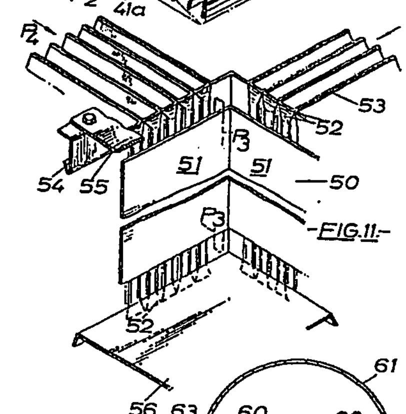
-FIG. 1.-


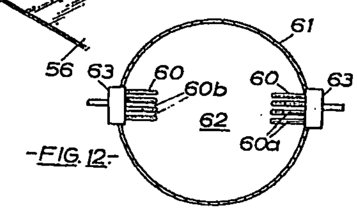
-FIG. 2.-

-FIG. 3.-



-FIG. 10.-


-FIG. 11.-



-FIG. 12.-

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Sheet 2